

## CLAIMS

What is claimed is:

1. A method for forming a dual damascene feature, comprising:  
  
forming vias in an etch layer;  
  
5 providing a trench patterned mask over the etch layer;  
  
etching a trench, wherein the etching the trench comprises a cycle of:  
  
forming protective sidewalls over the sidewalls of the vias; and  
  
etching a trench through the trench patterned mask; and  
  
stripping the mask.etching steps, including the stripping the mask  
  
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2. The method as recited in claim 1, wherein the trench cycle is repeated  
at least three times.
3. The method as recited in claim 1, wherein the trench etch cycle is  
15 repeated at least five times.
4. The method, as recited in claim 3, wherein the passivation and etching  
are performed in a common plasma processing chamber.
- 20 5. The method, as recited in claim 4, wherein the deposition uses a non-  
directional deposition and the etching step uses a directional etching.

6. The method, as recited in claim 5, wherein the wafer is bombarded by energetic ions with ionic energy greater than 100 ev during the deposition step.
7. The method, as recited in claim 5, wherein the passivation is a non-etching or a negligibly etching deposition.
8. The method, as recited in claim 5, wherein the deposition uses a gas mixture containing at least one of H<sub>2</sub>, CH<sub>3</sub>F, CH<sub>2</sub>F<sub>2</sub>, CHF<sub>3</sub>, C<sub>4</sub>F<sub>6</sub>, C<sub>4</sub>F<sub>8</sub> as the polymer former and at least one of CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, and NF<sub>3</sub> as the etching gas.
9. The method, as recited in claim 5, wherein the deposition step uses a mixture containing CF<sub>4</sub> and H<sub>2</sub>.
10. The method as recited in claim 9, wherein the CF<sub>4</sub> to H<sub>2</sub> gas flow ratio is in the range of 0.6:1 to 1.4:1 by volume flow rate.
11. The method, as recited in claim 7, wherein the deposition process is selected from at least one of chemical vapor deposition and sputtering.
12. The method, as recited in claim 1, wherein the etch layer is a low-k dielectric material.
13. The method, as recited in claim 1, wherein the via holes are not filled with a sacrificial filler material prior to the start of the trench plasma etching

process.

14. The method, as recited in claim 1, wherein the via holes are filled with  
a filler material to no more than 50% of the via hole height prior to the start of  
5 the trench plasma etching process.

15. A semiconductor formed by the method of claim 1.

16. An apparatus for performing the method of claim 1.

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17. An apparatus for etching a layer under an etch mask, wherein the layer  
is supported by a substrate, comprising:

a plasma processing chamber, comprising:

15 a chamber wall forming a plasma processing chamber  
enclosure;

a substrate support for supporting a substrate within the plasma  
processing chamber enclosure;

a pressure regulator for regulating the pressure in the plasma  
processing chamber enclosure;

20 at least one electrode for providing power to the plasma  
processing chamber enclosure for sustaining a plasma;

a gas inlet for providing gas into the plasma processing  
chamber enclosure; and

a gas outlet for exhausting gas from the plasma processing  
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chamber enclosure;

a deposition gas source;

an etchant gas source;

5 a first control valve in fluid connection between the gas inlet of the plasma processing chamber and the deposition gas source;

a second control valve in fluid connection between the gas inlet of the plasma processing chamber and the etchant gas source;

a controller controllably connected to the first control valve, the second control valve, and the at least one electrode, comprising:

10 at least one processor; and

computer readable media, comprising:

computer readable code for opening the first control valve for at least one deposition step to provide a deposition gas from the deposition gas source to the plasma processing chamber enclosure;

15 computer readable code for closing the second control valve for the at least one deposition step to prevent etching gas from the etchant gas source from entering the plasma processing chamber enclosure; and

20 computer readable code for opening the second control valve for at least one etching step to provide an etching gas from the etchant gas source to the plasma processing chamber.

18. The apparatus, as recited in claim 15, wherein the computer readable media further comprises computer readable code for performing the at least one deposition step and at least one etching step in an alternating fashion for a  
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plurality of times.

19. The apparatus, as recited in claim 16, wherein the etchant gas source  
comprises an etching gas component source and a polymer former gas  
5 component.